

APPENDIX E: Response To Alternative Scenario

Comments were submitted to CSB for its consideration of an alternative scenario to the one presented by CSB investigators at the Board of Inquiry in Reno, Nevada, on April 16, 1998. The alternative scenario contends that the PETN Building exploded first, followed by a blast seconds later in Booster Room 2, and that the initial blast was caused by possible sabotage to cover the theft of a large quantity of PETN or some other unknown reason.

This appendix contains the CSB investigators' response to this alternative scenario. It also contains a summary of the arguments opposing the CSB scenario, and the CSB investigators' response.

The comments did not provide any conclusive evidence or analysis causing the CSB investigation team to alter its conclusions regarding the sequence and cause of the explosion at the Kean Canyon plant. Subsequent examination of the evidence has actually strengthened the CSB's conclusions related to the sequence of the explosions, which refutes the claims made in the comments.

- The University of Nevada, Reno, provided an analysis of seismic data that their seismologists believe demonstrates conclusively, based on the relative locations of the blasts, that the first explosion occurred in Booster Room 2 and was followed by the explosion in the PETN Building.
- In addition, explosives modeling experts at the Department of Energy's Oak Ridge National Laboratory compared the quantities of explosives present in the two locations to the seismic data showing that the second blast was stronger than the first. They found the quantities of explosives correlated well with the first explosion occurring in Booster Room 2, followed by the explosion in the PETN Building.
- This information, coupled with the observation that the last movement of the flatbed truck located over the edge of the slope south of Booster Room 2 was uphill, away from the PETN crater, all prove that the sequence of explosions as described in this report is correct.

EVIDENCE RELATED TO THE SEQUENCE OF EXPLOSIONS

The comments regarding the sequence of explosions and the CSB investigators' response are summarized below.

1. **Comment:** The pattern in the grass on the hillside east of the plant cited by the BATF investigators on initial entry is not meaningful because of the distance from the grass to the buildings of about 200 feet.

CSB: The grass patterns observed by the BATF support the contention that the PETN Building explosion occurred second because the grass pointed away from that location.

2. **Comment:** A blast from the PETN explosion caused all the damage that resulted in the layering near the Hot Water Boiler Building. [This is the building CSB refers to as the “Boiler Building” and which is labeled “Main Electrical Panel and Boiler” in Figure 3.] The blast wave from the explosion in the PETN Building pressurized Booster Room 1, which blew out the seven- by ten-foot sliding door which provided access to the platform on the east side of Booster Room 1. The same blast wave destroyed the walls of the Hot Water Boiler Building and blew the west half of the roof north, where it came to rest leaning against the south wall of Booster Room 1 near the loading dock. The second half of the roof landed upside down on the sliding door.

CSB: Layering of material is considered by the investigation team to be a helpful indicator of sequence. The layering observations provide strong corroborating information that helped the investigators establish the sequence of events.

The first issue raised by the comment was whether there were three layers or two layers of material on top of the Booster Room 1 sliding panel door. There were three layers of material. The Boiler Building roof slab and concrete cap were clearly evident. Below the Boiler Building roof slab was another piece of concrete that was part of a wall of the Boiler Building. The chunk of concrete underneath the Boiler Building roof slab was sandwiched between the Boiler Building roof slab and the Booster Room 1 sliding panel door. This chunk of concrete from the Boiler Building wall was moved by the incident investigation team just prior to lifting the Booster Room 1 sliding panel door to inspect under it. The Boiler Building wall material was on the Booster Room 1 sliding panel door and was clearly not part of the Boiler Building roof slab. Rather, it was located between the two pieces. The ground under the Booster Room 1 sliding panel door was free of debris from the Boiler Building or the PETN Building. This fact establishes that the Booster Room 1 sliding panel door reached the ground before debris from either of these sources.

The second issued was whether the south wall of the Boiler Building moved through the Boiler Building. The comment quotes a statement made by a CSB investigator: “The south wall of the Boiler Building was essentially blown through the building and landed on top of that door, and then the roof came down on top of that, giving us three layers of material.” This response indicates the writer of the comment misconstrued this statement. From all of the comments, it is clear that the writer assumed the statement meant that the entire wall went through the building intact and landed on the sliding door. What was actually meant by the statement was that the south wall of the Boiler Building collapsed into the Boiler Building. The collapse of the south wall allowed the Boiler Building to be pressurized, causing the walls to move outward. Chunks of the Boiler Building’s concrete walls landed on top of the Booster Room 1 sliding door that was on the ground at the north-east corner of the Boiler Building. Only a small section of the Booster Room 1 sliding panel door had wall material on it.

The comment also questioned the movement of the Booster Room 1 sliding panel door. It concludes that it would be “very improbable that a blast effect from the PETN Building traveling south to north demolishing a massive concrete building in its path would not entrain the light-weight door panel.” This conclusion is not justified by the physical conditions present during the blast. There would be very turbulent conditions due to the effects of the topography of the site and the Boiler Building. It is more reasonable to conclude that the Booster Room 1 sliding panel door would remain on the ground, for two reasons: 1) the door panel was laying flat on the ground after the Booster Room 2 blast, and therefore had a low profile to the PETN blast effects, and 2) the Boiler Building shielded the ground behind it from the blast effects and therefore the Booster Room 1 sliding panel door remained in its final location.

The scenario proposed by the comment is not probable for an additional reason. The concept of the PETN Building blast causing the Booster Room 1 sliding panel door to be propelled to its final location so that the Boiler Building could fall on top of it is not credible. There were delays between the time the blast effects reached the Boiler Building and the same effects reached Booster Room 1. There were additional time delays needed to create the differential pressure to propel the Booster Room 1 sliding panel door from the building. There were still more delays needed for the door to travel from Booster Room 1 to the boiler room and land on the ground. Meanwhile, the Boiler Building walls, the tank, and the roof had only to fall to the ground with the aid of the blast. The scenario presented by the comment is highly unlikely given the photographic evidence of the undisturbed incident scene. Based on the physical evidence, the investigation team maintains that the source of differential pressure that led to the panel door movement was the explosion in Booster Room 2 and that the Booster Room 2 explosion occurred before the PETN Building explosion.

3. **Comment:** The configuration and construction of Booster Room 2 resulted in a highly directional blast which would have left the PETN crater free of debris if the second explosion had occurred in Booster Room 2. Further, the one piece of roof debris in the crater was cited as evidence that the first explosion occurred in the PETN Building.

CSB: (See response to comment 7.)

4. **Comment:** The PETN explosion propelled the empty pneumatic tank originally located at the corner of the change room to an intermediate position leaning against Booster Room 2. The second explosion in Booster Room 2 then blew the tank and components to their final locations. This is proposed as the explanation for the upper lid being found southwest and pneumatic piping that fed into the lid to the southeast. Splattering noted on the top of the pneumatic tank was the result of the Booster Room 2 explosion melting and dispersing roofing material onto the lid of the tank.

CSB: The sequence of events and explanation of the damage in this comment is not consistent with the actual damage sustained by the tank. The most significant contradiction in the comment’s description is that the conical section at the base of the tank was pushed into the cylindrical portion of the tank, turning that part of the tank inside out. If the tank was leaning up against the building as described by the comment after the PETN explosion, the

base of the tank would be pointing away from Booster Room 2 at the time of the Booster Room 2 explosion. This position would have resulted in greater damage to the sides and top of the tank and does not account for the base of the tank being turned inside out.

The sudden pressurization of the tank when the conical section was forced up through the base of the tank and violent acceleration due to the blast in Booster Room 2 explains the damage and eventual position of the various components of the tank.

The comment noted black spattering on the top of the tank lid, which they believe came from the asphalt roof material. There are many ways this material could have been deposited on the top of the tank. One of these is from the plume of the fire from the warehouse. Trucks in the lower Frehner Construction Company truck lot approximately 1200 feet from Booster Room 2 showed similar black spattering on the hoods.

Based on the physical evidence, the investigation team still concludes that the tank was damaged and propelled by the explosion in Booster Room 2. And that the location of the tank confirms the sequence of events to be first an explosion in Booster Room 2 followed by the PETN Building explosion.

5. **Comment:** The flatbed truck, which was facing east, and located just south of the change room, was struck by the blast from the PETN building which lifted the front of the truck and rotated it counter-clockwise 45-60 degrees to the north. The second blast from Booster Room 2 then propelled the truck south, where it came to rest on the edge of the terrace slope.

CSB: The comment has several major deficiencies. First, it does not address the riprap evidence (discussed in Section 3.4 of the report) showing that the last movement of the truck was uphill, away from the PETN Building and toward Booster Room 2. Second, the comment does not address the cargo rack being on the Booster Room 2 side of the truck on top of building debris, including part of the stand from one of the two small mixing pots. The other observations and conclusions in the comment are inconclusive because they are sequence independent (damage to cab and grill), can have multiple explanations (small piece of wood stuck in the grill), or are unsupported conclusions (breaking of the base plate weld).

Photographic evidence shows a piece of the sheet metal wall from the production buildings jammed up under the frame over the back side of the rear dual tires on the passenger side of the truck. The portion of this sheet metal that extended beyond the outside dual tire was wrapped up and back around the outer member of the flatbed frame. The siding was blown out by the Booster Room 2 explosion, struck and became affixed to the bottom of the truck frame. With the truck's intermediate position facing south over the brow of the slope, the PETN blast caught the exposed portion of sheet metal protruding from behind the back dual and pushed it up and around the outside member of the truck frame. This siding could not end up in this position if the truck was facing Booster Room 2 as proposed by the comment.

A piece of mixing pot fragment lodged in the driver's side of the engine block. The radiator and other engine components were displaced toward the passenger side of the vehicle. This shows that the truck was facing east when struck by the blast from Booster Room 2 and could not be facing Booster Room 2 as the comment contends.

Another inconsistency in this comment is the assumption that if the Booster Room 2 blast occurred first, the truck would have rolled over when the PETN Building blast struck it. The physical evidence does not support this assumption. The chassis of the truck was resting on the brow of the slope when the PETN Building explosion occurred. In this configuration the truck had a lower center of gravity and consequently was not overturned by the blast. However, using the comment's conclusion, if the PETN Building exploded first, then the truck should have been rolled over by that blast, which was strong enough to destroy the concrete Boiler Building and roll a pickup truck onto its side.

Because the last movement of the flatbed truck was away from the PETN Building, the CSB concludes that the first explosion occurred in Booster Room 2.

- 6. Comment:** All the damage to the pickup truck located south of the west door to Booster Room 1 was caused by the blast from the PETN building.

CSB: The dishing depression of the door sustained by the pickup truck is characteristic of blast damage and could not have been caused by the mirror mounting hardware. The damage to it was caused by an over-pressurization condition. The blast effects of the Booster Room 2 explosion blew out all the reinforced, solid-grouted concrete-block walls of Booster Room 2, turned over the forklift located in the warehouse, blew the sliding panel door off of Booster Room 1, and caused the east wall of Booster Room 1 to collapse into the Booster Room. This massive release of energy was sufficient to cause the blast damage to the pickup truck parked outside Booster Room 1. Because a day's production of boosters (3000 to 4000 pounds of explosives) were either boxed or in bins on the south side of Booster Room 2, which shared a common wall with the restroom/shower area, explosion of this material had no substantial barrier to prevent blast damage to the west.

The comment that pallets south of Booster Room 1 were not moved to the west is incorrect. Aerial photographs taken of the site after the explosions show pallets on the roadway west of their original position in addition to those that traveled northwest.

- 7. Comment:** There was no heavy high trajectory debris from Booster Room 2 found near the PETN Building of the type required to penetrate the steel reinforced roof or the skylight, which had a grill of rebar on 8-inch centers to prevent unauthorized entry. The roof of Booster Room 2, composed of plywood, 2 x4 wood trusses, and sheet metal roofing, could not produce the necessary missile. However, the roof of the PETN building could produce a missile that could penetrate the Booster Room 2 roof and strike the PETN stored there.

CSB: The comment asserts that, “It is to be noted that no heavy trajectory type material was found between the PETN Building and Booster Room 2 nor was any recognizable material fitting this description found within a 200 foot radius of the PETN Building.” That there is relatively little material from the booster manufacturing buildings found immediately near the PETN crater supports the conclusion that the PETN Building must have exploded after Booster Room 2. There were large items from the general location of Booster Room 2 found within and beyond a 200-foot radius, however.

That there is very little material inside the PETN Building crater is easily explained if the PETN Building explosion occurred second. The PETN Building explosion left a forty-foot diameter crater in its former location; it knocked over the Boiler Building; it rolled the pickup truck on its side; and deposited pieces of the PETN Building and its contents over 2000 feet away. One of the steel-plate sides of the PETN magazine, which was originally located on the south side and adjacent to the PETN Building, was thrown approximately 160 feet to the east-south-east. A single piece of metal roofing found in the crater after the PETN Building explosion must have had a high trajectory, which kept it in the air beyond the 3.5 seconds between explosions.

There were ample materials in Booster Room 2, including metal struts, pipes, I-beams, shafts, mixer components, and pieces of the concrete wall that could have had the correct trajectory and be energetic enough to penetrate the PETN Building. Booster Room 2 materials were found within the perimeter of the original Booster Room 2. Materials were also found adjacent to Booster Room 2, and in trajectories that crossed or pointed toward the PETN Building. Mixing pot 6 was located within 20 feet of Booster Room 2 to the south. The pneumatic tank had a trajectory that carried it toward the PETN Building. Also, a stand from one of the work tables in Booster Room 2 landed approximately 160 feet beyond the PETN Building on a trajectory from Booster Room 2 that passed over the PETN Building. Because of the energy released during the explosion in the PETN Building, it is reasonable to assume that any large object hitting and detonating the PETN Building would not be found near the crater. This is further supported by the finding that there were no pieces of the PETN Building or magazine near the PETN crater. The overpressure from the explosion in Booster Room 2 would have destroyed the skylight over the east end of the PETN Building. Thus, hot or burning debris falling through this opening could also have initiated detonation of the PETN.

The comment has not disproved or provided convincing evidence to alter the CSB team’s conclusion that the explosion in the PETN Building was initiated by effects from Booster Room 2.

8. **Comment:** The presence of stainless steel fragments north of Booster Room 2, which came from pot 4, shows that the initial explosion did not occur in pot 5; it exploded sympathetically with other explosives in the room.

CSB: The comment states that “If the small amount of explosives (approximately 50 lbs. in pot 5) had been the initial explosion in Booster Room 2, the thin wall stainless steel small pot situated to the east and slightly south of pot 5 would not have contributed any fragment debris to the north.” This conclusion is unsupported by the physical evidence.

Pot parts, especially large pieces, were primarily found to the East, South, and West of Booster Room 2. None of the larger pieces, such as shafts, upper assemblies, or intact mixing pots were found to the north of Booster Room 2. Mixing pot leg brackets from large mixing pots and a portion of a mixing blade from a large pot, however, were found north of Booster Room 2. The chaos in Booster Room 2 during the explosion, other explosions in the room, or explosions from the PETN Building could have propelled smaller objects to their final locations to the north. It is not possible or necessary to determine all of the forces acting upon all the material at the site. That pot parts were found in virtually all directions demonstrates the chaotic nature of the explosion. Most of the stainless steel fragments found to the north were from the inner wall of large pots, which were thicker than the walls of the smaller pots.

- 9. Comment:** The PETN ground level blast was concentrated in a narrow angle facing in a northwesterly direction. This rolled over the pickup truck in this zone, was witnessed by the worker boxing boosters in Booster Room 1, and propelled the witness against the west wall. The employee then heard a second explosion and the roof collapsed.

CSB: The blast sequence has been clearly established by the flatbed truck, layering, damage patterns, and other evidence. The observations and conclusions of individuals subjected to the explosion describing the conditions in the booster room are limited by their recollection of conditions that existed for milliseconds during the blasts. Perceptions of the direction of the blast are not valid given the conditions and the time for the boxer to observe the outside events from within the building out of the corner of his eye through a partially open sliding door. Given the setback of the truck from the edge of the slope, it is much more likely that the fireball seen by this worker originated from the explosion in the Booster Room 2 on the same level, than from the PETN Building 23 feet below the elevation of the witness and farther away.

The comment states the direction of ground blast effects were “narrowly concentrated” in a north-westerly direction. The blast was not focused. The PETN Building was located immediately south of a five-foot high riprapped slope leading up to the terrace below the production level. The PETN Building blast tore away a portion of the first berm on the north and deposited a fan of dirt on the next terrace and the riprapped slope to the production level. This gave the appearance of the blast being focused. In reality, the blast was essentially hemispheric, with blast effects in all directions.

Terracing and the pickup truck parked south of the PETN building’s open sliding door would have deflected the blast substantially. The line of sight from the center of the PETN crater to the open sliding door to Booster Room 1 was less than 20 degrees from being perpendicular to the south wall. Thus, the residual force would be directed more toward the north than toward the west wall where this witness landed.

There is independent corroboration that the first blast came from the east side of the room. The operator working beside the big pot in Booster Room 1 was thrown west across the room under the cooling bins toward the open door, rather than away from it.

The comment's discussion concerning the chevron pattern of the roof trusses in the warehouse supports the intensity of the blast emanating from Booster Room 2 but does not clarify explosion sequencing.

In the interviews of Booster Room 1 workers, no one ever described the piece of the roof of the Boiler Building coming through the south wall of Booster Room 1 just west of the loading dock. If the PETN Building detonated first, this would have occurred during the initial blast and would have been a significant event that the workers would have noticed.

Statements of the boxer in Booster Room 1 indicate that the first explosion threw him against the boxes stacked against the west wall, and caused the lights to fail and the roof to collapse. This sequence is confirmed in the interview he provided to the CSB. He then heard the second explosion, which was louder than the first, which is consistent with the larger quantity of PETN exploding after Booster Room 2. In another interview, of an operator in Booster Room 1, the operator stated that the roof collapsed after he heard the second explosion. This conflicts with the statements of Booster Room 1 workers interviewed by the CSB investigators.

- 10. Comment:** When the windows were blown out of the backhoe in the gravel pit, the supervisor driving was stunned for a moment and then looked over his shoulder and saw the explosion of Booster Room 2 with the building “flying apart” and a black cloud over the main operating buildings. He indicated that the PETN Building exploded first followed by that of Booster Room 2.

CSB: The comment states that “This stunned [the supervisor] and after a moment he thought the shattering of the glass had been caused by a blowout of the large pneumatic tire behind him to the right.” This assertion was directly contradicted during CSB’s interview with the worker’s supervisor. The Sierra legal representative was present when the supervisor stated clearly and unequivocally that the supervisor was not stunned and that he turned his head immediately to see what had happened. In spite of his conclusions, his description of the physical events does not support the PETN Building explosion being first. In fact, the supervisor never saw the PETN explosion. He assumed that the flash of light in the cab, the glass breakage, and blast he felt resulted from an explosion in the PETN Building.

- 11. Comment:** In accordance with provisions from the DoD proposed rule (32 CFR Part 184), *Contractors’ Safety for Ammunition and Explosives*, the protective construction provided in the design of the Sierra facilities serves as an alternative to the Institute of Makers of Explosives (IME) quantity-distance requirements. There are no quantity-distance requirements between working bays located in the same operating building since explosives were not transported from bay to bay. “Inhabited Building” separation distances are designed to protect the general public. Buildings occupied in connection with the manufacture, transportation, storage, or use of explosive materials are not considered to be “inhabited buildings” requiring this separation.

CSB: In this comment, the writer takes exception to the investigation team’s observation that the IME quantity-distance recommendations were not met at the Kean Canyon facility. The response contends that the interpretation made by the investigation team is in error and provided a memorandum from

an industry-hired investigator that states that “ ‘protective construction’ is allowed in order to ‘suppress explosion effects’ as an alternate to distances that may be listed in the q[quantity] d[istance] table.” It is unclear how this information, taken from a draft DoD standard, could apply to IME’s guidance.

The industry-hired investigator’s memorandum concludes that “Certainly the intent of ‘Section 184.44 (c)’ – to provide protection of personnel against death or serious injury against explosion communication between adjacent bays – can have no finer example than the design at Kean Canyon’s operating building. All the employees in the first bay, Booster Room 1, were protected when the explosion occurred in the second bay, Booster Room 2.”

The fatalities of the worker in the change room and the worker outside the flux manufacturing room, and the explosion in the PETN Building demonstrate that personnel and facilities adjacent or near to the booster manufacturing rooms were not protected. It is evident that the design did not effectively suppress explosion effects, as asserted by the memorandum. None of the construction at Kean Canyon could suppress the effects of several thousand pounds of explosives. Such a claim is ludicrous.

Section 3.2.16 of IME’s Publication 3, *Suggested Code of Regulations for the Manufacture, Transportation, Storage, Sale, Possession and Use of Explosive Materials*, states in part:

“High explosive manufacturing buildings located on explosive materials plant sites . . . shall be separated by minimum distances conforming to the requirements of the ‘Intra Plant Distance Table For Use Only Within Confines of Explosives Manufacturing Plants’.”

Using the 20,000 pounds of explosives in Booster Room 1 and assuming that the terracing served as an effective barricade between facilities, the required minimum separation distance between the PETN Building and Booster Room 1 would have been 265 feet, rather than the actual separation of 185 feet. The comment may argue that Booster Rooms 1 and 2 were bays in the same building and Intraplant Quantity-Distance requirements don’t apply between these bays. But if it is assumed that Booster Room 1 and 2 are explosive bays in the same building, the total quantity of explosives in the combined production buildings according to Sierra’s own estimates would have been 32,000 pounds and the minimum distance from the production building to the PETN Building would be 295 feet.

The “DoD Ammunition and Explosives Safety Standard” siting requirements state: “Administration and industrial areas shall be separated from potential explosive sites by inhabited building distances.” Because the minimum inhabited building distance is controlled by the fragment hazard distance of 1250 feet, the Frehner Construction Company gravel pit operations and the Sierra chemical operations did not meet this criteria.

- 12. Comment:** The only credible scenario to explain how the first explosion occurred in the PETN building is sabotage in an attempt to cover up the theft of PETN. Several individuals could easily transport a large quantity of PETN from the site by backpack.

CSB: Having set out to show that the first explosion occurred in the PETN Building, the comment concludes that the explosion was the result of sabotage to mask the theft of a large quantity of PETN explosive. This was the only initiating event possible in this locked building that was unoccupied with no equipment in operation in the cold early morning of January 7, 1998. Because the PETN Building was locked, access would require insider assistance. Otherwise the missing lock and/or damaged door would have been clearly evident the following morning. In fact, the supervisor and workers present that morning drove past the door to the PETN Building and did not detect anything unusual the day of the incident. Setting off a delayed explosion to mask a theft and yet provide time to escape would require experience in the use of explosives and a timer to delay the ignition. The National BATF team members are trained to look for evidence of such devices, but found none. There was no indication that any of the workers other than the supervisor had ever detonated any explosives, and the supervisor's experience was limited to the testing of boosters. The gate into Sierra's Kean Canyon Plant was locked during off-hours and the Frehner Construction Company guard who monitored traffic into the site was located near that gate.

- 13. Comment:** The CSB either misquoted or distorted testimony [interviews]. The CSB's investigators' statements that the operation was not controlled by any management system; that individuals were encourage to create processes that were efficient; that operators changed their processes as they liked; and that they did not require other outside reviews or independent oversight of those actions and might not even communicate to others what they were doing, are all evidence of this. Management felt it had strict control, consistent and frequent overview, and repetitive training to control the operation.

CSB: Multiple witness interviews support the conclusions made by the incident investigation team.

- 14. Comment:** A double-axle trash trailer parked near the edge of the terrace south of Booster Room 2 and the Flux Room, was propelled into the wall of the flux room by the PETN explosion and then southeast by the explosion in Booster Room 2.

CSB: This evidence is not useful for establishing sequence. The trailer could have first been blown down to a lower terrace by the explosion in Booster Room 2 and then blow east by the explosion in the PETN Building. Alternately, the original location could have been further east than believed, such that the Booster Room 2 explosion blew the trailer components directly to their final resting points. The CSB investigators did not examine this issue because the preponderance of other evidence supported the CSB scenario.

- 15. Comment:** A vertical metal wall panel from the south wall of the flux room has damage to the first 18 inches of the panel consisting of indentations and sandblasting while the top of the panel is shredded outwards. The damage at the bottom was caused by crushed rock south of the concrete apron being blown by the PETN explosion against the wall. The Booster Room 2 explosion then caused the shredding damage.

CSB: The CSB investigators did not examine this wall panel, but believes that there are other explanations that could account for such damage. The shredding of the wall panel was most likely caused by the blast from Booster Room 2; however, the damage to the lower portion of the panel could have been caused on impact or by its orientation to the effects of the second blast from the PETN Building explosion.

16. Comment: The roof of Booster Room 2 consisted of plywood covered by galvanized sheet metal panels, which were later covered by plywood and a fiberglass-asphalt top layer. Some galvanized sheet metal panels were found north of Booster Room 2 that show penetrations from both sides. Falling debris from the PETN explosion caused penetrations from one side followed by fragmentation from the Booster Room 2 explosion.

CSB: The CSB investigators did not examine this evidence. It is likely that all of this damage resulted from the blast in Booster Room 2, however. Some penetrations that appear to be from the top could have resulted from the sheet metal being blown away from roof trusses. Fasteners pulling through the sheet metal could give the appearance of a penetration from above. Due to the separation of explosives within the room and the generation of primary and secondary fragments, it is possible for the fragments from Booster Room 2 to have penetrated both sides of the roofing. Other penetrations could simply be due to the exposed panel being struck by falling metal fragments after the explosions.

17. Comment: An empty tank was strapped on a low-boy trailer east north east of the PETN Building on the same terrace. The PETN explosion struck the rear of the trailer and propelled it, and pieces of the tank along a line from the PETN building through the original location of the trailer. If Booster Room 2 had exploded first, the blast would have hit the side of the tank and propelled it south.

CSB: Because of the 80-foot setback of Booster Room 2 from the edge of the terrace to the south and the difference in elevations, the tank on the lowboy would not experience the direct impact of the blast that it would have experienced if it had been located on the same level. The trailer and tank were also partially shielded by a storage unit that was visible to the investigators. The tank was well secured to the trailer so the trailer itself kept the tank from being propelled south. Thus, this evidence was not seen as useful in establishing sequence.

EVIDENCE RELATED TO THE CSB'S INCIDENT SCENARIOS

The comments in response to the scenarios presented by the CSB investigators are presented below with the CSB's responses.

18. Comment: The use of sparking steel hammers or carpenters' hammers to break up explosives does not seem probable and was most likely a mistranslation of what was actually said. The supervisor stated that the use of steel hammers was strictly forbidden due to their spark potential. It appears, however, that workers, in violation of rules, occasionally used steel hammers and such use was quickly stopped.

CSB: There are multiple references in CSB interviews of Sierra employees to the use of steel hammers to break up lumps of Comp-B or reject boosters, and one employee's statements clarified the type of steel hammer they used as a carpenter's hammer. The scenario proposed by the CSB, however, had nothing to do with sparking. The detonation was due to "impact or impingement of explosives between the hammer and either a foreign object in the material or another hard surface." This result is possible whether the hammer was made of steel or a nonsparking material like bronze.

- 19. Comment:** Turning on the agitator to pot 5 with solidified explosives present is not credible because the pots were left steam heated at night at a temperature of 180 degrees F, the operator who saw the residual explosives in this pot stated that the level was approximately 1 1/2 inches below the mixing blades, it was standard procedure to inspect the pots prior to activating the agitator, and the overload circuit protector was set to trip if the mix became too thick.

CSB: a) Cooling/solidification

The owner of Sierra stated that he asked the operators to leave one valve on each pot cracked open to ensure that the boiler would cycle to prevent freezing. He indicated from his observations that the temperature in the steam jacket would be 90-100 degrees. He confirmed that if explosives were left in the pot overnight, they would solidify. The morning of the incident was one of the coldest days that winter, which would further increase the likelihood that the explosives had solidified. Worker statements indicated that sometimes no valves were left cracked open.

It was standard practice for operators to shut off the valves and add flake TNT to bring the temperature of the mix down to get the proper viscosity. Because the operator who left explosives in his pot in Booster Room 2 may well have thought that his co-worker was going to use the remaining base mix, he could have left the steam valves to that kettle off in order to maintain the proper consistency. The co-worker indicated that typically, the Booster Room 2 operator who left explosives in his pot would leave the steam valve opened slightly to the draw-off line. The co-worker, however, did not check or open any valves on pot 5.

b) Mix Level

The co-worker told CSB investigators that the remaining base mix left in pot 5 was three to four inches deep and half-way up the hub at the base of the stirring blade. In the alternative scenario, it appears that this worker may have been stating that the level was 1 to 1 1/2 inches below the top of the stirring blade hub, which would be consistent with his earlier statements. The entire blade was not encased in solidified explosives. The mixing blades had only about one inch of clearance between the blade and the inner pot wall, as described in management interviews. Thus, the lowest portion of the blade extended into the solidified explosives.

CSB investigators also did an independent calculation using the inside diameter from drawings provided by Sierra to estimate the level based on the worker's estimate of quantity (one bucket full, about 50 pounds). The results were as follows:

2 inches	13.1 pounds
3 inches	28.8 pounds
4 inches	50.3 pounds
5 inches	77.0 pounds
6 inches	108.5 pounds

Thus, the worker statements we received concerning the amount of explosives left in pot 5 was supported by the calculation.

c) Failure to Inspect Pot

One operator working in Booster Room 2 did not feel the need to look inside his mixing pots every time. Another worker who had worked a few days in Booster Room 2 stated that he didn't think that the operator who left material in pot 5 normally looked into his pots before he turned the mixer on.

d) Spark/Pressure

The mixer used with the pots are capable of delivering over 4,000 inch pounds of torque (based on a manufacture's calculation dated January 30, 1998). This is more than enough torque energy to cause a detonation. The motor overloads in the mixers do not instantaneously drop out and were set at 8.5 to 9 amps (based on photographic evidence and manufacture's interpretation of the setting). Since only the lowest portion of the blade extended into the solidified explosives near the central mixing shaft, the explosives provided much less resistance to the torque of the mixing blade.

20. Comment: A spark from the mixing pot striking metallic debris in Comp-B is improbable because: 1) the operator would not have reached the point in the process in which Comp-B is poured into pot 5; 2) metal fragments were typically too small to be caught in the one-inch clearance between the agitator and pot wall; 3) Sierra had not had such an event over the past 25-year history using manual screening; and 4) the quality of reclaimed government explosives was improving.

CSB: The CSB scenario was misquoted by the comment. The actual scenario involved detonation of explosives by impact, friction, or shearing when foreign materials or hard lumps of Comp-B or substitute materials were added to the mixing pot. A bolt could easily be of sufficient size to be caught between the blade and the inner wall of the pot. Previously, the Comp-B pot in Booster Room 1 had sustained damage from foreign materials being caught between the mixing blade and the wall. The CSB investigators' timelines for each scenario were based on operators' accounts of the startup

sequence. There was enough variation in this sequence that it is impossible to know exactly how the operator in Booster Room 2 was conducting his operation the morning of the incident. Sierra's manual screening process failed to eliminate foreign materials. This is clearly evident because most foreign materials were discovered in the pot after the pour.

21. Comment: Initiation by static electricity resulting from pouring dry PETN or drying PETN in the mixing pot is improbable. PETN was not dried in Pentolite pots before adding TNT, because this would cause clumping of the mixture, which would slow production. Also, the incident occurred before the operator would have reached this point in the operation.

CSB: The statements of the senior operator in Booster Room 2 clearly described the process of dry mixing of PETN to reduce residual moisture. When questioned further, he provided several assurances about putting the PETN in the pot without TNT. He did it all the time. This was the same operator responsible for training the other operators in Booster Room 2.

An operator normally would not begin with the Pentolite Pot. If the operator working the morning of the incident checked and saw the residual solidified base mix, however, he might have gone ahead and started the Pentolite mix while the base mix melted.